Southwest Research Institute
San Antonio, Texas 78228

NAGW-1621

IN-90-CR

176413

NASA-CR-193350

P 3

Final Report
30 June 1991

NASA Grant: NAGW-1621
SwRI Project Number: 15-2772-001

Study Of The Plasma Dynamics
In The Inner Coma
Of Comet P/Halley

1. Objectives

The purpose of this proposal was to look at the plasma dynamics within the inner coma of Comet P/Halley, in particular, the dynamics which specifically delt with and resulted from the presence of suprathermal ions. All of the inner coma models used today consider the inner coma to be an environment which is purely cometary in origin. In this respect the inner coma is simply a cold expanding neutral and plasma gas which is built from parent molecules and atoms originating at the nucleus together with the molecules and atoms which they spawn through chemical, photochemical, and collisional processes. The passage of the Giotto satellite through the inner coma showed that in addition to this low temperature ionospheric gas there is a large suprathermal ion component. The origin of this component has not been determined although several hypothesis have been put forward. Because a large percentage of the cometary community still was not convinced that these measurements even represented uncontaminated data we felt that it was time to present a conclusive study of the suprathermal ions.

2. Approach

This work was carried out primarily using the ion measurements supplied by the Johnstone Plasma Analyzer which was on board the Giotto satellite. This data set which had yet to be reported on in any detail contained the only complete medium energy plasma record (>10eV and <24keV) within the inner coma. There were three problems which had to be overcome. The first of these was the existance of light comtamination within the experiment which rendered several of the angular sectors of the data unusable. Using a statistical subtraction algorithm we were able to remove the light contamination from the data prior to the data loss at closest approach. This increased the usable portion of the data by about 30%. After closest approach the satellite developed a large nutation which caused the telemetry to be periodically lost on the ground. The data tapes provided by ESA of this time period contained a very poor merging the satellite data from the three tracking ground stations. By hand merging the telemetry from the three ground stations we were able to increase the available data near and after closest approach by another 20 to 30%. Lastly after closest approach the instrument picked up an overall background count rate which was removed through the subtraction of a universal background. Once the data were cleaned we applied the suite of common analysis routines to it to obtain a set of relavant parameters which could be used in interpretation of the data. This included formation of the plasma parameters from the density up to the heat flux and generation of high resolution phase space contours.

3. Conclusions

The first goal of this study was to determine if the measured data was due to effects of the cometary environment or was due to an indegineous suprathermal ion presence within the inner coma. The extremely high relative velocity of the satellite with respect to the comet made the first postulate highly likely and was the main reason that many believed that the observed suprathermal ions were not part of the inner coma. The effects that were considered included the effects of the plasma sheath which surrounded the satellite, sputtering off of the satellite forward shield and the effects of the vaporization of dust grains impacting both the satellite and the instrument. Careful analysis showed that these effects probably made only a small contribution to the measured data. The measured data then represents an accurate picture of the suprathermal ion component within the inner coma.

With this result, the data could be considered as being at least a temporary feature of the inner coma. This led to a study of the possible sources for these ions which resulted in a publication entitled "Ion Acceleration at the Contact Surface of Comet P/Halley" of a paper in The Journal of Geophysical Research. The major conclusions of this paper are itemized below.

1. The suprathermal ions within the inner coma fall into two distinct populations which are distinguished by their energy ranges. One population has a continuum of energies below about 400 eV and the other is almost monoenergetic with energies centered at about 3500 eV.

2. One source of suprathermal ions may be the contact surface. Movement of the contact surface within the comet reference frame will give rise to an induction electric field which can accelerate local thermal ions up to 10's to 100's of eV.

3. The suprathermal ions represent an extremely large percentage of the energy budget of the total inner coma. This may reach as high as 50% at the closest approach of the Giotto satellite.

4. The suprathermal ions represent an extremely large pressure at the contact surface which as of now has not been included in any of the force balance equations used to predict the location of the contact surface.

The higher energy suprathermal ions appear not only monoenergetic but also appear to be able to traverse the inner coma with minor energy loss. These and other features point to a different source for these ions that those in the lower energy population. We began a study of these ions which is about to be submitted to The Journal of Geophysical Research. The conclusions of this paper are itemized below.

1. By simulating both the observed energy and density changes in the particle population across the inner coma we have concluded that these ions are primarily

protons.

2. In order to obtain an almost monoenergetic ion energy which is much higher than it would appear can be obtained locally in the region of the contact surface we have postulated an energetic neutral source. Here picked up protons are energized by the interplanetary electric field. Reneutralizing a fraction of these ions creates a flux of energetic neutrals some of which will intersect the inner coma. The neutrals, which have free access to the inner coma are reionized to form the high energy background.

Publications

Gurgiolo, C. and J. D. Winningham, Ion Acceleration at the contact surface of comet P/Halley, *J. Geophys. Res., 95, 17051*, 1990.

Gurgiolo, C. and J. D. Winningham, Reply *Submitted to J. Geophys. Res.,*, 1991.

Gurgiolo, C., D. Boice, W. Huebner, and J. D. Winningham, A source of high energy suprathermal ions in the inner coma of P/Halley *To be submitted to: J. Geophys. Res.,*, 1991.